

25. v^{ch}l obr ild xni bnim xm eaēd plg ki biniv nplge cary v xm aēiv iqtln
 Eber Peleg Peleg Joktan
26. v iqtln ild at-almudd v at-xlp v at-evrmut v at-irē^{ch}
 Joktan Almodad Sheleph Hazarmaveth Jerah
27. v at-edurm v at-auzl v at-dqle
 Hadoram Uzal Diklah
28. v at-oubl v at-abimal v at-xba
 Obal Abimael Sheba
29. v at-aupr v at-ēvile v at-iubb kl-ale bni iqtln^{ch}
 Ophir Havilah Jobab Joktan
30. v i-i maxbm m-mxa bake spre er eqdm
 Mesha Sephar
31. ale bni-xm lmxpēt^{ch}m llxgtm barytm lguiem
 Shem
32. ale mxpēt bni-nē^{ch} ltuldtm bguiem umale nprdu eguim bary aēr embul^{ch}
 Noah

ALSO OF JUDGES XII, 6.

v iamru lu amr-na xblt v iamr sblt v la ikin l dbr bn v iaēzu autu v ix-^{ch}
 Shibboleth Sibboleth
 ethuēu al mobrut eirden v ipl bot ceia maprim arboim v xnim alp.

On the Grapeville Gas-wells. By J. P. Lesley.

(*Read before the American Philosophical Society, March 6, 1891.*)

Mr. John Fulton, General Manager of the Cambria Iron Works, at Johnstown, Cambria county, Pa., has kindly furnished me with the following particulars of one of the most important and significant episodes in the strange story of Petroleum in Pennsylvania :

1. A report to him made October 12, 1888, by Edgar G. Tuttle, then Mining Engineer of the Company. This gives :—(a) the number of wells (27 or more) around Grapeville, in Westmoreland county, up to that date sunk and piped by different companies ;—(b) the length and sizes of the pipe line to Johnstown ;—(c) the pressures of gas at the well, at the 4th, 8th, 12th, 16th, 20th, 24th, 28th, 32d, 36th and 39th mile, and at the Cambria Works terminus.

2. A second report made to him two years later, February 25, 1891, by M. G. Moore, now Mining Engineer of the Company. This gives :—(a) the titles of eleven companies owning 85 gas-wells in the Grapeville district ;—(b) an account of the drilling especially of the Agnew well ;—(c) a table showing the decline of pressure at the Westmoreland and Cambria Companies' wells, from 386 lbs. on April 29, 1889, to 65 lbs. on February 2, 1891 ;—(d) a full table of the Co.'s thirteen wells, depths, dates of striking gas, the initial pressure of each, subsequently observed pressure at April 29, 1889, December 15, May 26, November 3, December 1, 1890,

January 5 and February 2, 1891, the first six wells starting with 460 lbs. and ending with 70 and 65 lbs. ;—(e) a diagram of the mode of piping the Agnew well ;—(f) a map of the country between Pittsburgh and Johnstown, showing location of groups of wells.

Mr. Fulton was prompted to sending me the data described above by his remembrance of my address, some years ago, at Pittsburgh, before the American Institute of Mining Engineers, in which I reiterated my belief on geological grounds in the comparatively speedy extinction of the rock gas industry of the country. He adds : " You will notice that recently one of the wells [at Grapeville] has been deepened to reach the 'Gordon sand,' and that a small supply of gas was found in this second and lower horizon of natural gas, but not enough to warrant any hopefulness of its maintaining the supply. A part of our works are being supplied yet with the natural gas from Grapeville, but it is weakening so fast that we have got to supplement it with artificial gases " (February 26, 1891).

My warrant for publishing in the Proceedings of this Society these most important geological and historical data is found in Mr. Fulton's words : " I do not think that there is anything in this report that is so private or confidential that it should not be made known; and you can therefore use the matter in these reports as you think wise. At the Cambria works we are using the Archer oil gas to take the place of the natural gas, and we are finding this to be a very good substitute. As you know, the Archer process consists in vaporizing fuel oil, and mixing at a very high heat steam with the oil. We have also opened our mines again here and are using coal in a great many sections of the works " (March 13, 1891).

October 12, 1888, the Westmoreland and Cambria Natural Oil Company owned seven (7) wells, located principally along Brush Creek, northeast of Grapeville, Westmoreland county, Pa. Three wells were connected with the pipe line; the others were held in reserve, two of them being drilled to a thin crust of hard rock (silica) just overlying the gas sand, which served as a hermetical cover to prevent the escape of the gas, even at its high pressure in the gravel-sand rock beneath it.

This fact is important as explanatory of the retention of the gas in the rock for past ages.

The wells are 1100 to 1400 feet deep, according to their locality in the valley or on the hill, the gas rock lying nearly horizontal.

The pipe in the well is of 5 inch diameter.

The two wells, A, A', on the map, were turned on full for the pipe to Johnstown, the well R being turned on more or less as a regulator of the supply at the Cambria works.

The pressure at top of well was 335 lbs., as the 10-inch main to Johnstown would not stand a much higher pressure.

There seemed no difference in strength or volume of gas per minute blown off (free) by one of these wells, in Mr. Tuttle's presence, compared with that which he saw two years before at a free blow from a well just north of Grapeville Station.

The gauges were noted often, so as not to permit the pressure to rise much above 335 lbs. ; and when this seemed likely to occur well R was shut sufficiently to reduce it again to 335. Formerly a weighted safety-valve, allowing a free blow, was used. Saturday evenings wells A, A¹ were closed, and only R used. "The gas in this field is not being wasted as formerly, or as greatly as it has been in the Murraysville field ; and the prospects are that the Grapeville field will last the longer of the two."

"I understand that the flowing pressure in the Murraysville field is now [October 12, 1888] 250 lbs. The Grapeville wells have great volume. When one is blowing off in the air and then is shut quickly, the gauge runs up in fifteen or twenty seconds to 525 lbs. In some districts the wells require a minute, and even longer, to reach their normal of 500 lbs. The weaker or low-pressure wells require days to reach their normal pressure."

As it is impossible to store or tank gas, wells are now drilled to within a few feet of the gas horizon and "held" there. When the supply from other wells weakens, these wells are sunk into the gas rock, one after the other, to keep up the supply.

Wells that have broke through to the gas are restrained by a "packer," a thick, heavy rubber cylinder, 20 inches long, outside diameter $\frac{1}{2}$ inch less than bore of well, fastened at the ends to the pipe going into the well (see cuts). The end of this pipe fits into the end of another pipe, making a "slip joint;" rubber flush with the outer diameter of the pipe; lower joint generally perforated to admit the gas; pipe A lowered into the well (and, if necessary, pressed down) to slip into pipe B, bulging the rubber packer against the sides of the well, and effectually stopping the rise of the gas *outside* the pipes. It can then be controlled by a valve at the top of pipe A, at the well mouth. Before this invention the gas could be held only below a certain pressure, above which it would force its way between the pipe and the sides of the well and blow the whole casing into the air. The economy to a district of the new "packer" is evident.

"At present (October 12, 1888) there appears to be no weakening of the supply, except when unusual and sudden demands are made on the gas. If the supply weakens, or a greater supply is needed, more wells may be added to the line. This may require the laying of more pipe, or the replacing of the present 10-inch main by a larger one. The W. & C. Company own about 20,000 acres, controlling a large part of the gas field."

The companies and wells around Grapeville in 1888 were as follows :

Westmoreland and Cambria, 7 wells, drilled between 1885 and 1888, three of them piped to Johnstown.

Carnegie, 6 wells.

Southwest, 2 or more, piped to Connellsville, etc. (drilling also on Brush Creek).

Greensburg Fuel, 2 wells, piped to Greensburg.

Jeanette Glass Works, 2, piped one mile west to the works.

Philadelphia Co., drilling near New Salem.

Owners unknown, 8 or more wells.

The W. & C. Co. have also seven wells (about 1400' deep), three miles northwest of Latrobe, on a northeast and southwest line $2\frac{1}{2}$ miles long. The northern three have a 6 inch pipe to Latrobe. The other four have a 10 inch pipe running east by Derry Station, P. R. R., to Laurel Hill, where it feeds into the Grapeville-Johnstown main about ten miles from Johnstown. The flowing pressure of the wells supplying Johnstown is 200 to 275 lbs. per square inch. That of those supplying Latrobe, 90 lbs.

Trial wells east of this field have been unsuccessful, very little gas being found.

Salt water flowed from some of the Latrobe group of wells.

The first and most northern well, the Fowler, was drilled in 1885, the last and southernmost, Miller, No. 3, in 1887. Their volume of gas does not equal that of the Grapeville wells, and requires a much longer time to gauge up to the same normal of 500 lbs.

The proposition at first made to land owners, to pay \$40 or \$50 for a 50 lb. well, and \$1.00 extra for each additional pound, was *not* generally accepted.

Pressures along the main at every four miles (taken in 1886 and 1887) show the loss of pressure by friction in a pipe of 10'', increasing to 12'', 16'' and 20'', thus :

For first 20 miles 3250', *ten* inch pipe of $\frac{3}{8}$ in. wrought iron.

For next 12 miles, *twelve* inch pipe of $\frac{1}{4}$ inch " "

For next $7\frac{3}{4}$ miles, *sixteen* inch pipe of $\frac{5}{16}$ in. cast "

For last $1\frac{3}{4}$ miles, *twenty* inch pipe of (?) " "

In the first column of the following table H. S. means High side. At the 39th mile, the gauge is at "Reducer low side." C. W. means the Cambria Works at Johnstown.

Table of Pressures to Show Loss by Friction.

Distance from well.	Size of pipe.	1886.	1886. Nov. 13.	1887. March.	1887. March 15.
0	10 in.	155 lbs.	200 lbs.	320 lbs.	333 lbs.
4	"	140	182	313	320
8	"	132	170	283	295
12	"	120	148	255	261
16	"	112	129	208	212
20	"	84	100	166	168
24	12 in.	75	85	132	130
28	"	63	70	95	95
32	16 in.	55	53	75	76
36	"	53	51	54	37
H.S.	"	52	50	53	36
39	"	20	—	25	25
C.W.	20 in.	20	—	25	25

Table of Wells and Ownerships, February 25, 1891.

Greensburg Fuel Gas Company	5	wells.
Southwest Natural Gas Company	9	"
Versailles Natural Gas Company	3	"
Youghiogheny Gas Company	3	"
Jeanette Glass Works.....	4	"
Manor and Irwin Gas Company	2	"
Westmoreland Specialty Company.....	1	"
Westmoreland and Cambria Natural Gas Company ...	13	"
Carnegie Brothers & Company	11	"
Philadelphia Natural Gas Company	23	"
National Tube Works.....	6	"
Total number reported by M. G. Moore	85	

The W. & C. Company's 13 wells are all piped to Johnstown. Their depths and pressures at various dates may be found on a following table. The deeper are on the hilltops. They all get their gas in the Gants sand rock of Washington county. Well No. 12 was deepened with the design to reach a lower gas sand horizon; but the rope was cut by the sharp sand driven up by the gas issuing from the Gants sand. Before the tools could get through it they were lost, and fishing tools also afterwards; so the well was abandoned, and No. 13 (Agnew well) was drilled a short distance south of No. 12.

This new Agnew well reached the Gants sand January 15, 1891, went through it, and was cased with 8-inch pipe; packed just above the top of the sand; supplied with another inner 6-inch pipe; packed again at the bottom of the sand; and the Gants sand gas between the pipes laid into the Johnstown main.

Drilling was resumed through the 6-inch pipe, and stopped, February 21, 1891, at 2700 feet. The "Gordon sand" was found at 175 feet beneath the Gants sand, was 35 feet thick, and gave gas at only 30 lbs. pressure, which, however, in twenty minutes rose to 175 lbs., "when it was necessary to discontinue the test;" why is not explained. "While the pressure in the Gordon is now (February 25) very much greater than in the Gants, the volume is much less, as is clearly shown by comparing the minute pressures; that of the Gants being 65, and of the Gordon only 30 lbs." [A diagram of the pipe and packing arrangement for passing through the Gants sand, and drawing off its gas to Johnstown, is appended to Mr. Moore's report.]

Below the Gordon sand, for 1070 feet to the bottom of the well, not a sign of gas or gas rock was observable. [This only bears out all Mr. J. F. Carrl's observations, published in his reports on the oil regions, especially his Seventh Report, I 5, just published by the Geological Survey of Pennsylvania.] The failure of the Agnew well to get a good supply from the Gordon sand does not necessarily condemn it over the whole Grape-

ville field, as it may be found in better condition in the central and northern parts of the field. Carnegie Bros. have begun drilling two or three wells to test the Gordon sand a little north of the centre of the Gants field, a mile from No. 10 (Sylvis well).

None of the Latrobe wells are piped to Johnstown.

Grapeville.—Table of Minute Pressures at Various Dates.

No.	Name.	Depth.	Struck Gas.	At First.	Apr. 29, 1889.	Dec. 15, 1889.	May 26, 1890.	Nov. 3, 1890.	Dec. 1, 1890.	Jan. 5, 1891.	Feb. 2, 1891.
1	Klingensmith	1100'	Feb. 13, '86	460	390	250	180	100	95	75	65
2	Henry.....	1133'	June, 1886	"	380	260	170	105	100	"	70
3	Moore.....	1149'	" "	"	390	"	175	100	95	"	65
4	Welker.....	1144'	Oct., "	"	380	"	170	105	100		
5	Brown.....	1224'	May, 1887	"	390	"	180	100	95	75	65
6	Ferree.....	1312'	Aug., "	"	380	240	170	"	100	"	70
7	Minsinger ...	1466'	Nov. 21, "	410	390	"	"	95	85	55	40
8	Shutts.....	1468'	Feb. 13, '89	380	"	250	165	100	"	70	60
9	Kipple.....	1360'	Nov. 30, '89	260		260	"	"	95	75	65
10	Sylvis.....	1357'	Jan. 13, '90	235			170	105	100	"	75
11	Truxel.....	1267'	Feb. 20, '90	235			180	100	95	"	"
12	Byers.....	1350'	Oct., 1890	125							60
13	Agnew.....	1420'	Jan., 1891	75							65

The steady decline in minute pressure from 386 lbs. on April 20, 1889, to 65 lbs. on February 2, 1891, predicts a speedy extinction of the use of natural gas at the Cambria Works.

Calculating the average rate per day of the observed decrease we find it to be as follows:

From April 29, 1889,	646 days,	321 lbs.	2 lbs. per day.
From Dec. 16, 1889,	413 "	188 "	2.200 "
From May 26, 1890,	252 "	107 "	2.355 "
From Nov. 3, 1890,	91 "	36 "	2.525 "
From Dec. 1, 1890,	63 "	30 "	2.100 "
From Jan. 5, 1891,	28 "	7 "	4 lbs. "

I take this opportunity to suggest that we have in the decline of gas pressure in all wells of all gas regions the most cogent of arguments against the theory that *gas pressure* is produced by the *hydrostatic pressure* of the locality. For, it is self-evident that the hydrostatic pressure must remain always the same, and therefore cannot be the *vis a tergo* of a variable oil or gas pressure; otherwise this last should also remain constant to the last drop of oil and the last cubic foot of gas coming from the well. The gradual decline of gas pressure in every well and all wells is proof positive that it represents the gradual exhaustion of an *inherent force of self-expansion* not dependent upon any *hydraulic vis a tergo*.